Certain Data on the Causes of Earth Currents

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Author's Abstract: Expounded are the results of a study on the daily (24-hour) variations in terrestrial currents according to data obtained in observations carried out during July-August 1939 and September 1940 in the region of the Kremenchug magnetic anomaly and near the village of Pisarevka (in Ukrainian SSR). The results of harmonic analysis of the mean-daily (24-hour) variations in terrestrial currents are compared with the corresponding elements of the variations in the Earth's magnetic field.

The physical nature of Earth, or terrestrial [telluric], currents has not yet been definitely explained. Most investigators look for the causes of this phenomenon in the inductive influence of geomagnetic variations. The observations completed have always given contradictory results. In certain places in the middle latitudes (1), the relations (ratios) between the electrical and magnetic variations obtained were such as if the terrestrial currents in the meridional direction were the results of the induction of the magnetic field, but the currents in the latitudinal direction, on the contrary, themselves actuated the magnetic variations. In a number of cases the observed daily (24-hour) variations in the terrestrial currents generally differed in their

character from the geomagnetic variations (2). Therefore it has been concluded from this in recent times that the terrestrial currents are mainly purely local phenomenon, not connected directly with the phenomena geomagnetism (2, 3).

In the present work we consider, from this point of view, data on new observations of terrestrial currents, which (data) we obtained at the Kremenchug magnetic anomly (Lat. 49°10', Long. 33°45') during July-August 1939 and near the village of Pisarevka (Lat. 50°35', Long. 29°00'; Ukraine) during September 1940.

Measurements of currents in the first and second parts (namely, Kremenchug and Pisarevka, respectively) were carried out with the aid of photo-recorders operating continuously around the clock. The measuring lines (made of PSM conductor wire) were laid in the directions of the true meridian and geographic latitude). Their length was about 1 km. Records of the main installations were duplicated in other still shorter parallel lines (200-800 m). Grounding of the measuring contours was effected by means of copper non-polarizing electrodes. The photo-records of the recorders were processed by the usual methods employed in observatories. Mean-hourly ordinates were averaged in both cases for the entire period of observations and only according to weakly-excited and steady ("resting") days in the magnetic relation (ratio).

In exactly the same way we averaged also the data of geomagnetic observations which we obtained at the Stepanov magnetic observatory. It geographic position differs in latitude from the first part [Kremenchug] by 2°31' and from the second part [Pisarevka] by 3° 41. The recording of the magnetic field on the anomly itself did not disclose any marked differences in the character of the daily (24-hour) behavior, or course, from the normal.

The mean-daily magnitude of the resulting potential gradient at Kremenchug was obtained as 10.5 mV/km, directed according to the true azimuth 105° (its component to the south 2.8, to the east 10.2). At Pisarevka its value reached 56.8 mV/km with azimuth of the direction 231° (its component to the south 35.2, to the west 44.1).

The varying part of the potential gradient in the first case amounted to about 90% of its total magnitude; in the second, to 40%. Simultaneous recording on the parallel lines showed that the constant component of the gradient is due mainly to the differences of potentials of local origin. A certain part of the component is always created also by electrode potentials. In connection with these, the obtained directions of the potential gradients cannot correspond to the true direction of the strictly terrestrial currents.

The mean-daily variations of the gradient are exhibited by the deviations in its mean-hourly values from the mean-daily value, in consequence of which the result is already freed, in the familiar degree, from a similar kind of local influences and electrode effects. The data of harmonic analysis of the daily (24-hour) behavior, or course, of the meridional (ΔN) and latitudinal (ΔW) components of the gradient is given in the attached table, which also contains the time derivatives of the curves of the daily course of the northern ($\Delta X'$) and eastern ($\Delta Y'$) components of the geomagnetic field strength, for the sake of quantitative comparison.

The graphic representation of the synthesized values of each series of the table is shown in the attached graph.

Almost complete convergence (agreement) is observed in the character of the variations of the potential gradient at Kremenchug and Pisarevka, inspite of the essential difference in the geographic position of these parts. On the graphs of ΔN, this is expressed less clearly in consequence of the different

degree of limitation in the variations of the resulting gradient's intensity (in the first part, in the limits of 15°; and in the second part, 4°). The noncoincidence of the amplitudes of variations can be explained by the difference in the electrical resistance of the minerals.

In addition the daily (24-hour) behavior (course) of ΔN and ΔW in both cases is obtained almost exactly of the kind that one should expect (4) if one considers the terrestrial currents as direct consequences of the electromagnetic induction due to the daily variations in the geomagnetic field. In this case, however, the graphs of ΔN appear as though displaced on the time axis relatively to the curves of $\Delta Y'$: in the first part, to the left by 1 hour 30 minutes; and in the the second part, to the right by 2 hours. A less notable systematic displacement exists also between ΔW and $\Delta X'$ for the village of Pisarevka. It is interesting that the displacement between ΔN and $\Delta Y'$ at Kremenchug is created mainly by a fluctuation with an 8-hour period (3rd harmonic) coinciding in phase with the fluctuation, of the same period, of the component ΔW. Such a coincidence indicates the absence of variations in the direction of the resulting gradient, which absence is observed at Pisarevka in the course of 24 hours.

Comparison of ΔN at Pisarevka with the daily course of the eastern component of the magnetic field (ΔY) indicates that, although they also agree in phase in the region of the diurnal (daytime) maximum and minimum, ΔY shows no evening maximum which appears on ΔN at around 1700 o'clock, and is repeated one hour later by the curve of $\Delta Y'$. Namely, consequently, a displacement of phases between ΔN and $\Delta Y'$ takes place here, but no inductive influence of ΔN on ΔY, as ordinarily admitted in similar cases (4). The causes of these phase dis-

placements are probably connected with the inhomogeneities of the electrical resistance of the Earth's crust.

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[Table and graph follow]

Table

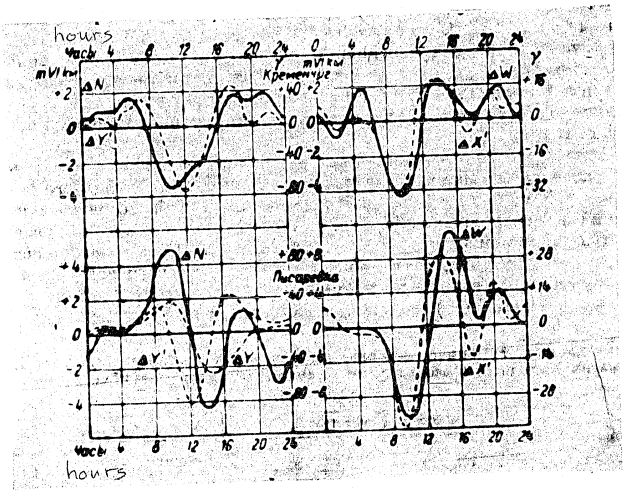
Table of data of harmonic analysis of mean-daily variations in terrestrial currents and geomagnetic field (the phase angles are reckoned from midnight according to Moscow time)

Amplitude and phase	July - August 1939 Earth Currents Kremenchug ΔN	ΔW	Magnetic Field Stepanovka ΔY'	ΔX'	September 1940 Earth Currents Pisarevka ΔN	ΔW	Magnetic Field Stepanovka ΔY'	ΔX'
	mV/km	mV/km			mV/km	mV/km		
C_1	2.1	1.6	23.6	11.2	1.9	4.5	18.7	11.3
C_2	1.4	1.4	33.0	10.9	1.8	4.1	32.0	12.0
C_3	0.4	1.7	17.9	12.9	2.2	3.7	23.5	13.7
C_4	0.3	0.2	2.2	3.2	0.3	1.7	9.9	8.2
C_5	0.4	0.2	5.2	2.7	0.3	0.7	3.2	3.4
C_6	0.2	0.3	5.9	4.6	0.1	0.4	1.9	4.6
	100*	143	92	166	333	162	105	164
	276	340	269	19	208	342	262	26
	191	198	77	207	0	165	74	204
	79	82	168	56	132	304	259	10
	262	317	248	354	21	8	70	359
	308	21	273	113	8	99	14	122

(*Note: All values of the phase angles are in degrees).

Graph

The connection of daily variations in terrestrial currents and geomagnetic field. The positive values correspond to directions of: ΔN to the north, ΔW to the west, ΔX' to the true north, and ΔY' to the east. The hours are indicated according to Moscow time.



Kremenchug

Pisarevka

- E N D -